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DESIGN AND OPERATING PARAMETERS FOR EMISSION CONTROL STUDIES: WHITE PINE COPPER SMELTER

I. J. Weisenberg, et al

Pacific Environmental Services,
Incorporated

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DESIGN AND OPERATING PARAMETERS FOR EMISSION CONTROL STUDIES: White Pine Copper Smelter

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16. ABSTRACT The report gives background design data for a specific copper smelter. The data is sufficiently detailed to allow air pollution control system engineering studies to be conducted. These studies will be concerned primarily with lean SO2 streams that currently are not being captured. Physical layout of the smelter and the surrounding area is presented, along with existing control equipment. Ductwork that would be considered for future system tie-in is defined. Emissions from operating equipment, gas flow rates, temperatures, sulfur balance, and a process flow sheet are included. Utilities, stack dimensions, footing requirements, and solid waste handling are defined. Available area for new control equipment, gas characteristic variation, and potential new control equipment installation problems are discussed.

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Design	Operating Data	
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by

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Contract No. 68-02-1405, Task 5
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THE FIGURES IN THIS DOCUMENT ARE NONREPRODUCIBLE

THEREFORE ARE EXCLUDED FROM THIS REPORT.

A. INTRODUCTION AND SUMMARY

The purpose of this report is to present background design data on the White Pine Copper Company smelter operation at White Pine, Michigan in sufficient detail to allow air pollution control system engineering studies to be conducted. These studies will be primarily concerned with lean SO_2 streams that are currently not being captured.

Physical layout of the smelter and surrounding area along with existing smelter and control equipment is presented. Ductwork that would be considered for future system tie-in is defined. Emissions from operating equipment, gas flow rates, temperatures, sulfur balance and process flow sheet are included. Utilities, stack dimensions, footing requirements, and solid waste handling are defined. Available area for new control equipment, gas characteristic variation and potential new control equipment installation problems are discussed.

There is presently no SO_2 control at this smelter. The major uncontrolled sources of SO_2 and particulate being the reverberatory furnaces and the converters. Approximately 78,500 tons per year of SO_2 and 2500 tons per year of particulate are emitted. There appears to be sufficient space and utility availability to install additional control equipment. The ore used has a much lower sulfur content than the ore processed at Western smelters. Due to the lower sulfur input SO_2 emission, fugitive losses in particular, are less than normally encountered.

B. PLANT LOCATION, ACCESS AND OVERALL GENERAL ARRANGEMENT

The White Pine Copper Company smelter is located adjacent to the town of White Pine, Michigan about 5 miles from Lake Superior. Figure 1, reproduced from a USGS map, shows the topography of the immediate area. The plant site elevation is 880 feet MSL. The plant site coordinates are latitude 46^{o}-46' N and longitude 89^{o}-36' W.

The overall plant site is shown in Figure 2. The smelter portion of the plant consists of the initial ore handling and mixing equipment, a rotary dryer, two reverberatory furnaces, two converters, two fire refining furnaces, two continuous casting machines, and a casting wheel.

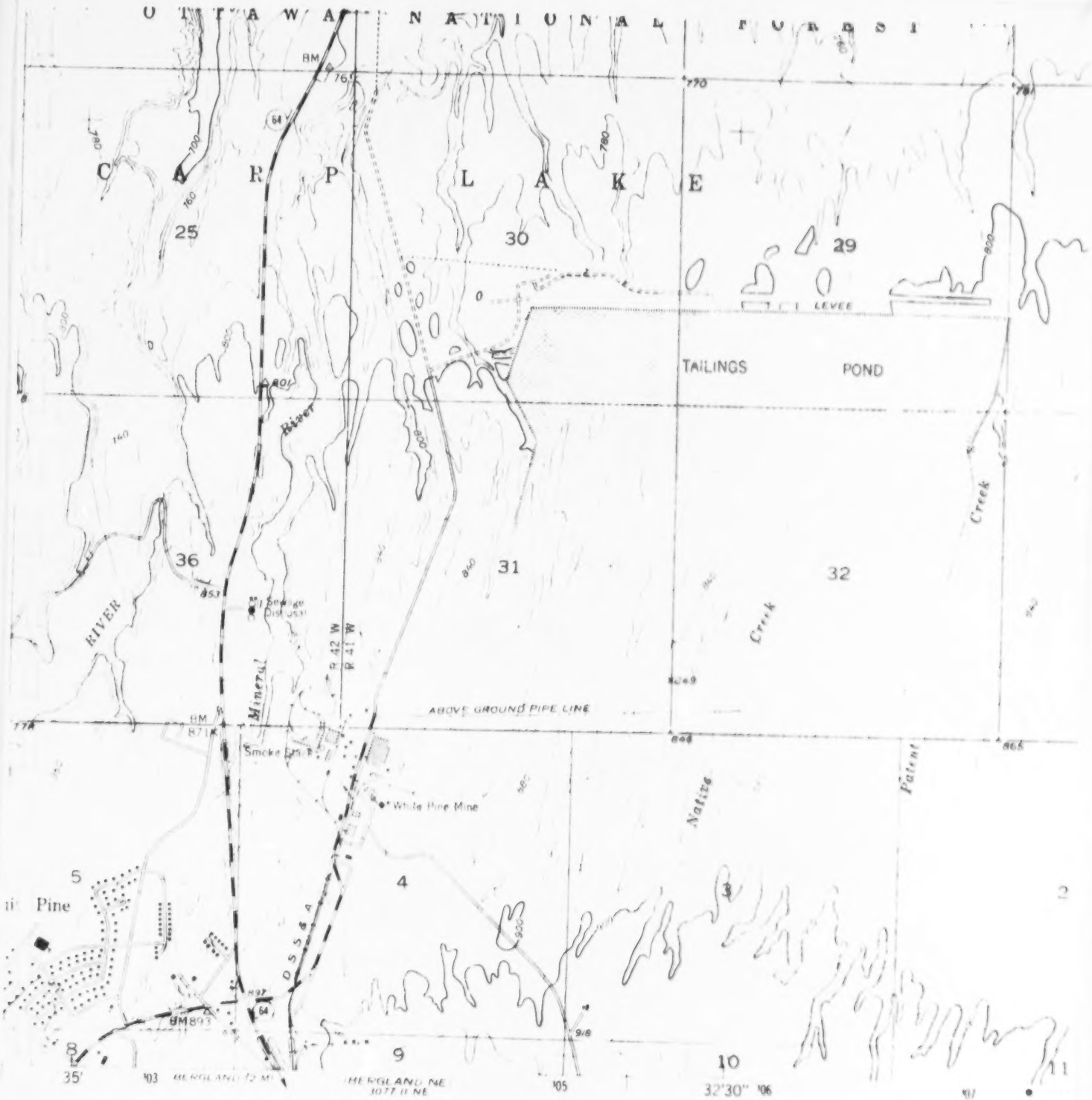

O T T A W A N A T I O N A L F O R E S T
C A R P L A K E
25
30
29
36
31
32
TAILINGS POND
LEVEE
ABOVE GROUND PIPE LINE
RIVER
Creek
Mineral
R 42 W
R 41 W
White Pine Mine
Pine
5
4
3
2
8
9
10
11
35'
32'30"
SCALE 1:24000
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL
DEPTH CURVES AND SOUNDINGS IN FEET - DATUM IS 601 FEET
MICHIGAN

Figure 1.

FIGURE 2.

OVERALL PLANT GENERAL ARRANGEMENT

(LOCATED IN ENVELOPE INSIDE BACK COVER.)

The pollution control equipment consists of a two-stage wet scrubber to remove particulate matter from the rotary dryer flue gas, and an electrostatic precipitator to clean the reverberatory furnace effluent. There is no sulfur dioxide control equipment at the smelter. Converter and reverberatory flue gases are emitted to the atmosphere from a 504-foot stack. A separate 90-foot stack handles the refining furnace flue gas.

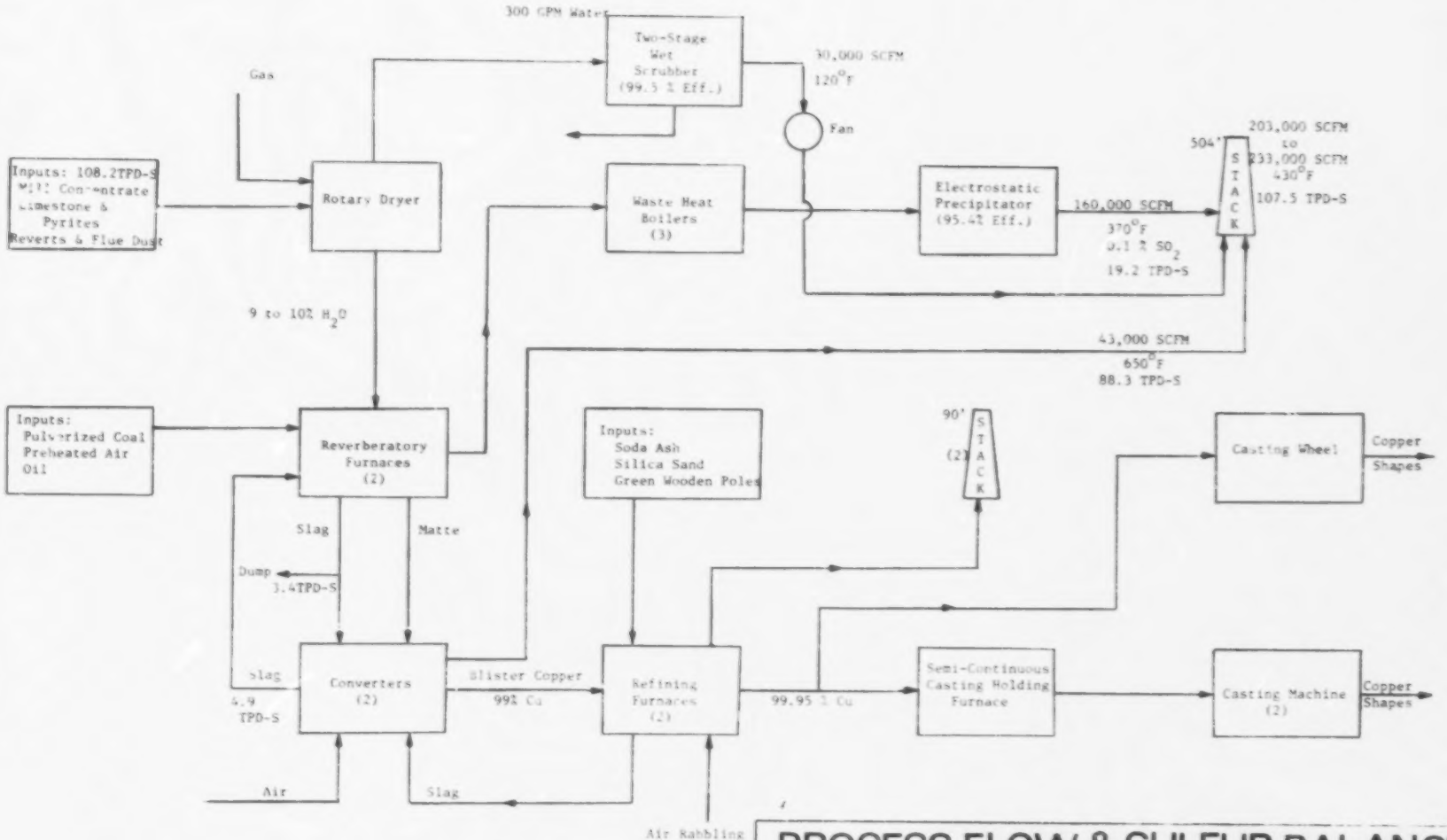
As seen in Figure 2, available space for new control equipment could be found south of the Smelter Building or west of the Reverberatory Furnace Building No. 2.

C. PROCESS DESCRIPTION

The smelter flow sheet diagram is shown in Figure 3. The feed in the form of mill concentrate or filter cake (approximately 30-32% copper and 18-22% moisture) is mixed with limestone, pyrite, and recycle material. The ore is mined underground in the vicinity of the smelter. It is considerably lower in sulfur content than Western ores. Additional sulfur must be added in the form of pyrite for metallurgical and handling control because of the low availabliity of sulfur in the ore. On a dry basis, the mixed charge contains 68% mill concentrate, 19% limestone, 8% pyrite, and 4% recycle material, by volume.

A large rotary dryer reduces the mixed charge moisture content to the range of 9 to 10% H_2O. A network of conveyors transport the dryer fluxed charge to two reverberatory furnaces. The reverberatory furnaces are fired with a fuel mixture of pulverized coal and preheated air. The matte produced in the reverberatory operation is transported in large ladles to one of two converters. Blister copper (99% copper) produced in the converters is transferred to one of two fire refining furnaces. The refining furnaces are charged with 240 tons of blister copper and approximately 8,000 pounds of soda ash. To lower the oxygen content of the copper, green hardwood poles are inserted into the molten material. Copper with 99.95% purity is produced for casting. Wheel casting and semi-continuous casting machines are operated at the smelter.

Gases from the rotary dryer pass through a two-stage wet scrubber with 99.5% particulate matter collection efficiency, then out the stack. Gases from the reverberatory furnaces pass through waste heat boilers and



PROCESS FLOW & SULFUR BALANCE

WHITE FINE SMELTER, W.P. Michigan | Prepared August 1975

PACIFIC ENVIRONMENTAL SERVICES

Figure 3

are transported by a balloon flue to an electrostatic precipitator where 95.4% (rated efficiency) of the particulate matter is removed. The cleaned gas is discharged from a 504 foot stack. Converter gases pass through a balloon flue directly to the 504 foot stack.

Temperatures, volumetric gas flows, and SO_2 percentages are shown on the process flow sheet. Appendix A is a detailed process description provided by the smelter.

D. EQUIPMENT

a. Reverberatory Furnaces

Two reverberatory furnaces are installed at the White Pine Smelter Operation. Dimensions are 120 feet long by 40 feet wide by 27 feet high. A top charge tripper system in each furnace building feeds the furnaces which take a side-wall charge. Figure 4 shows the furnaces in plan view and Figure 5 furnace elevation with uptake to the waste heat boilers.

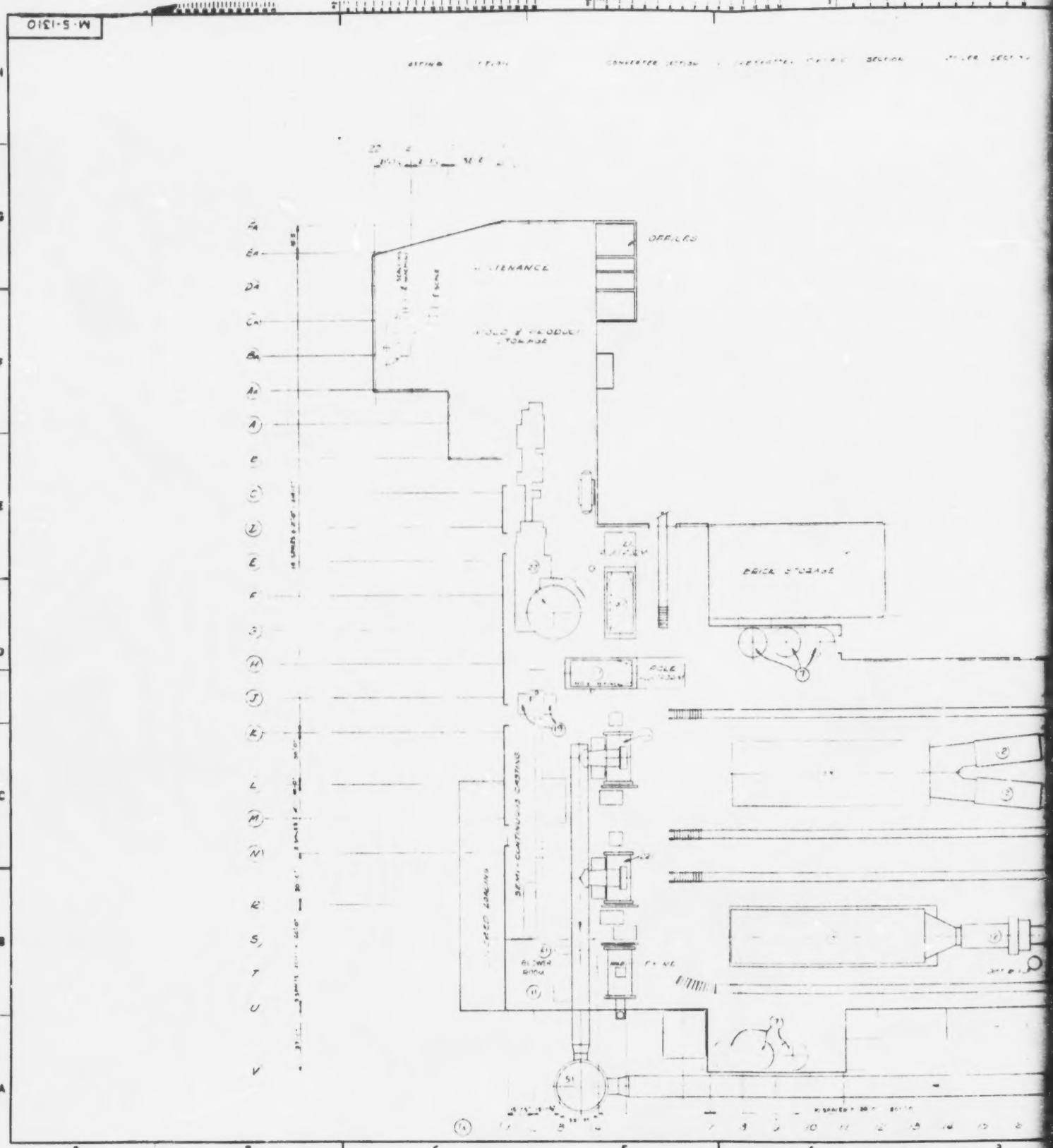
As seen in Figure 4, one reverberatory furnace is equipped with a single waste heat boiler, while the other furnace is equipped with a paif of waste heat boilers. The single waste heat boiler has a design rating of 68,000 lb/hr of steam and normally operates at about 80,000 lb/hr of steam. The pair of waste heat boilers are each rated at 77,000 lb/hr and normally operate at 80,000 lb/hr of steam.

b. Converters

There are two Peirce-Smith converters 13 feet in diameter by 30 feet long. Figure 4 shows plan view location of the converters and Figure 6 shows elevation with offgas hood arrangement.

c. Dryer

One Koppers direct fired rotary dryer 10 feet diameter by 70 feet long is used to prepare the furnace charge. Natural gas consumption averages


M-5-1310
MAINTENANCE
OFFICES
BRICK STORAGE
SEMI-CONTINUOUS CASTING
SPEED LOADING
BLOWER ROOM
8
7
6
5
4
3
H
G
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E
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A

A

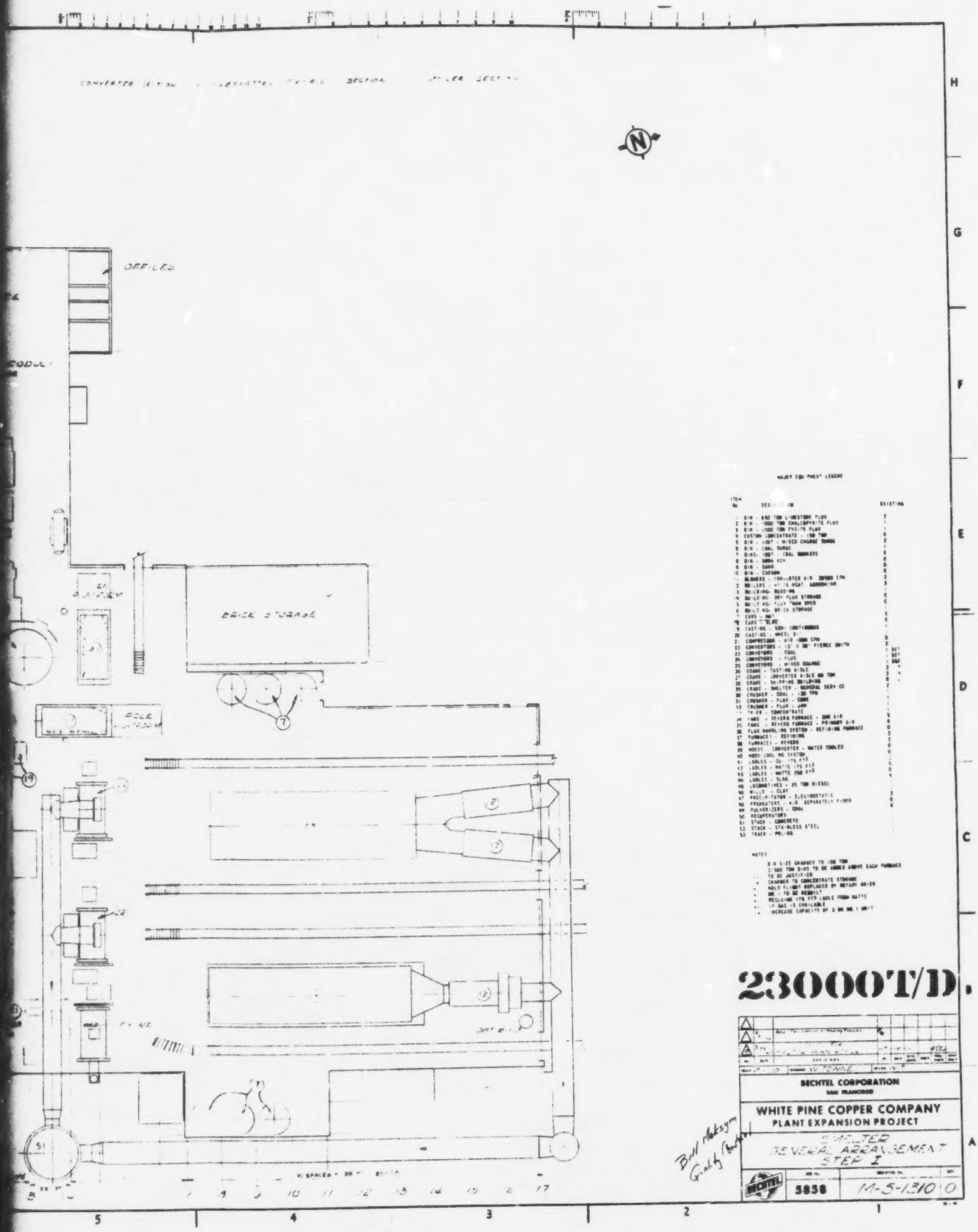
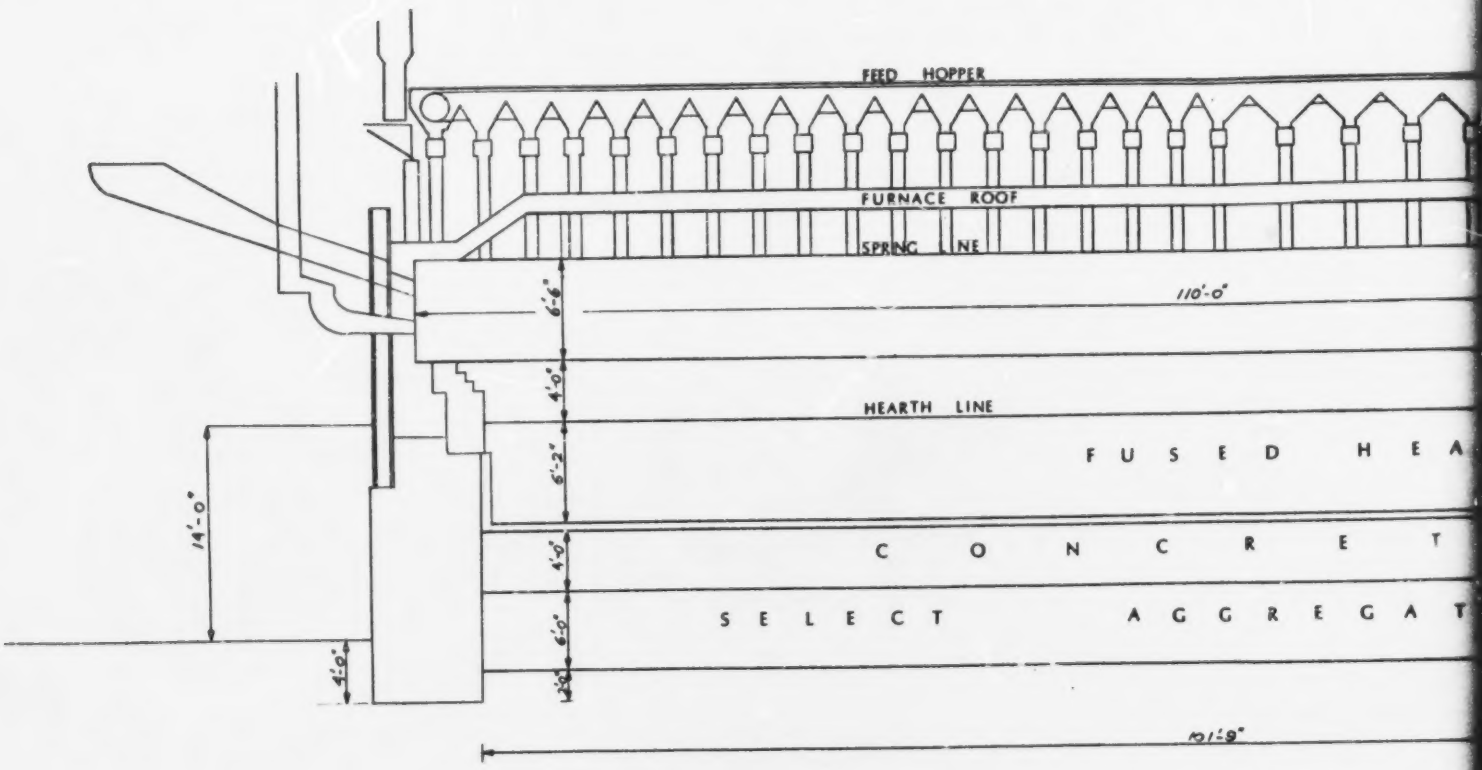
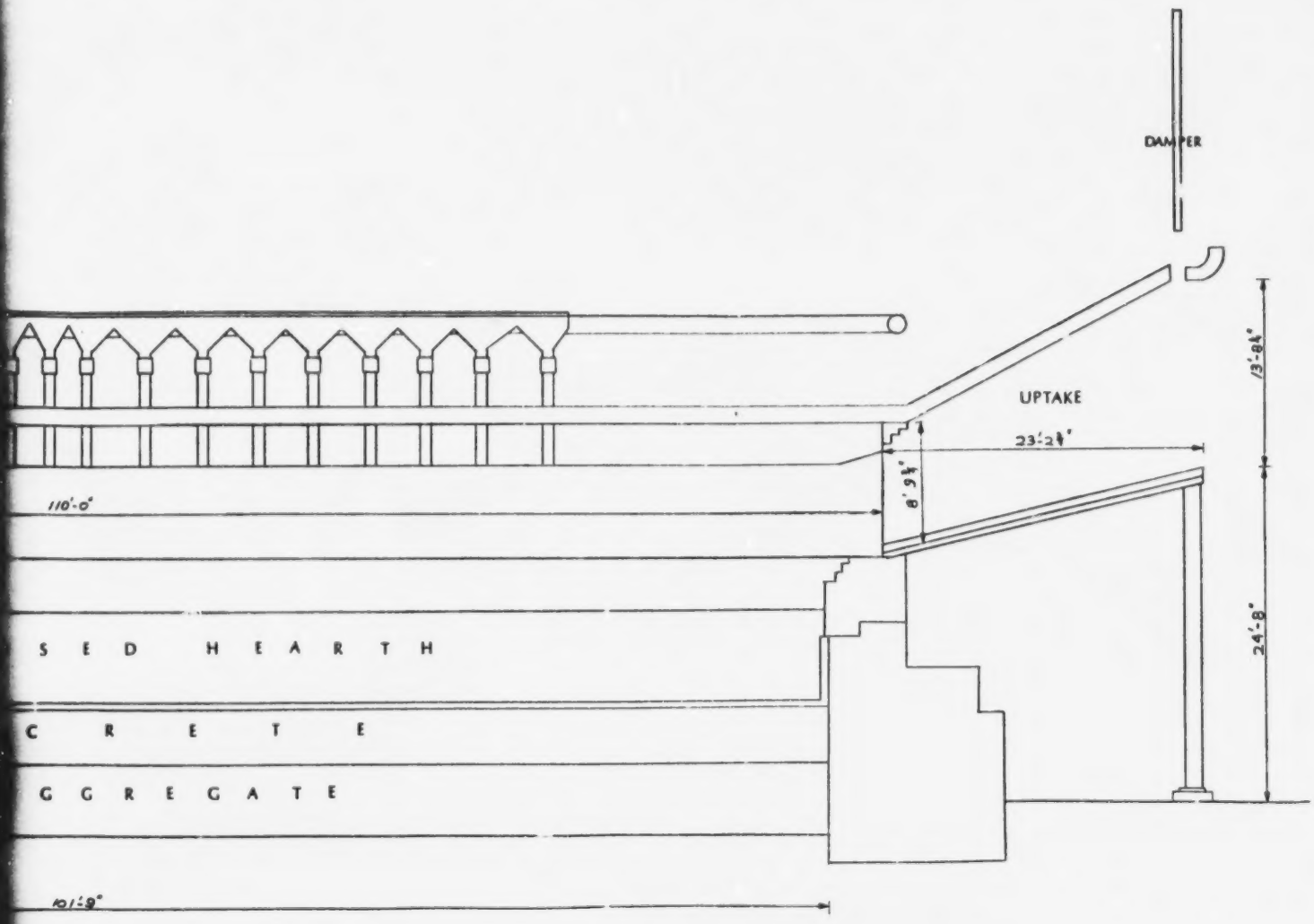

DRILLED
BRICK STORAGE
230001/D.
BECHTEL CORPORATION
SAN FRANCISCO
WHITE PINE COPPER COMPANY
PLANT EXPANSION PROJECT
SMELTER
REVERB. ARRANGEMENT
STEP I
5858
M-5-1310
0

Figure 4



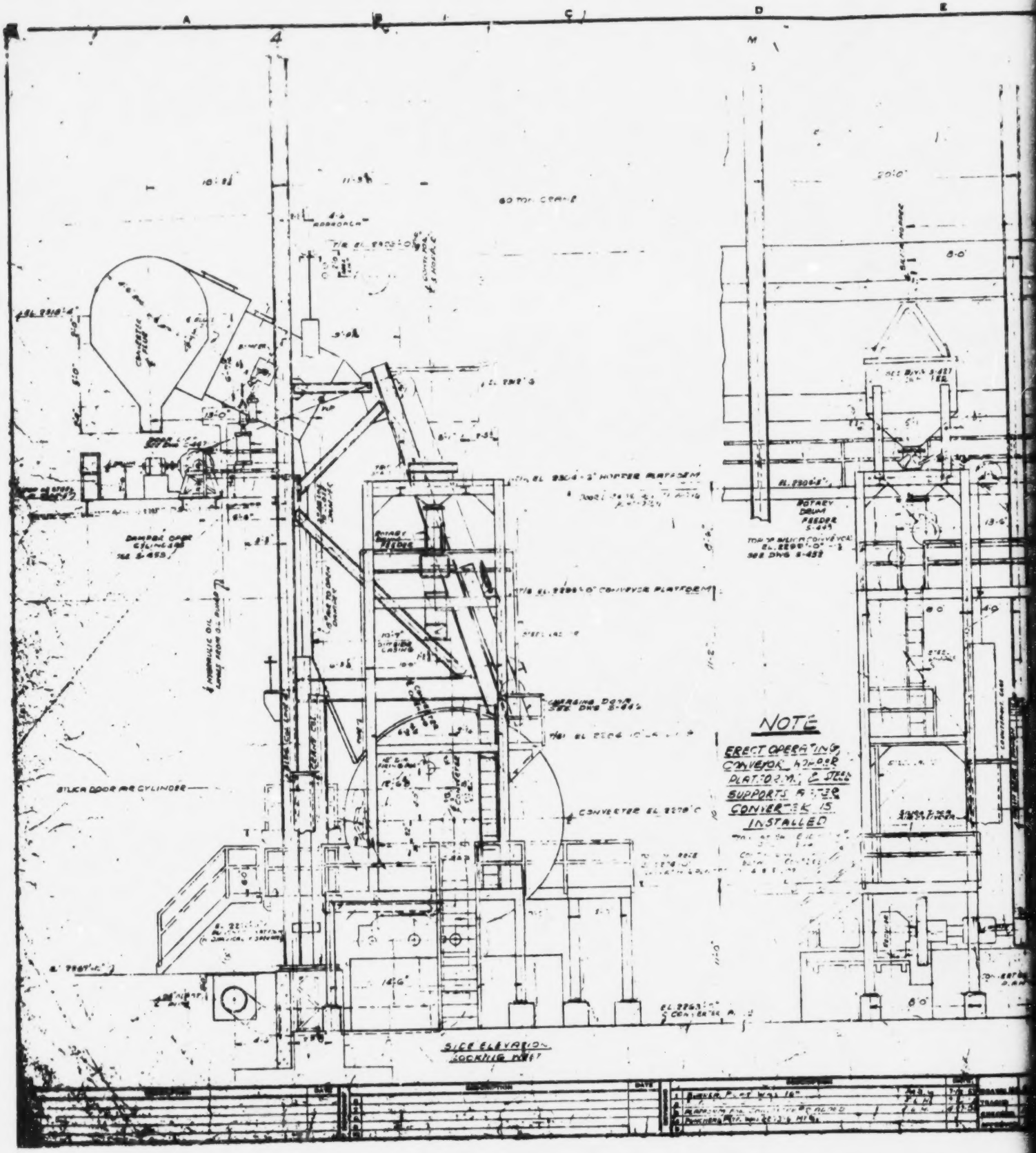
REVERBERATORY FURNA



ERATORY FURNACE

B

Figure 5


A
B
C
D
E
4
60 TON CRANE
SILICA DOOR AIR CYLINDER
NOTE
ERECT OPERATING CONVEYOR PLATFORM & STEEL SUPPORTS AFTER CONVEYOR IS INSTALLED
SLICE ELEVATION LOOKING EAST

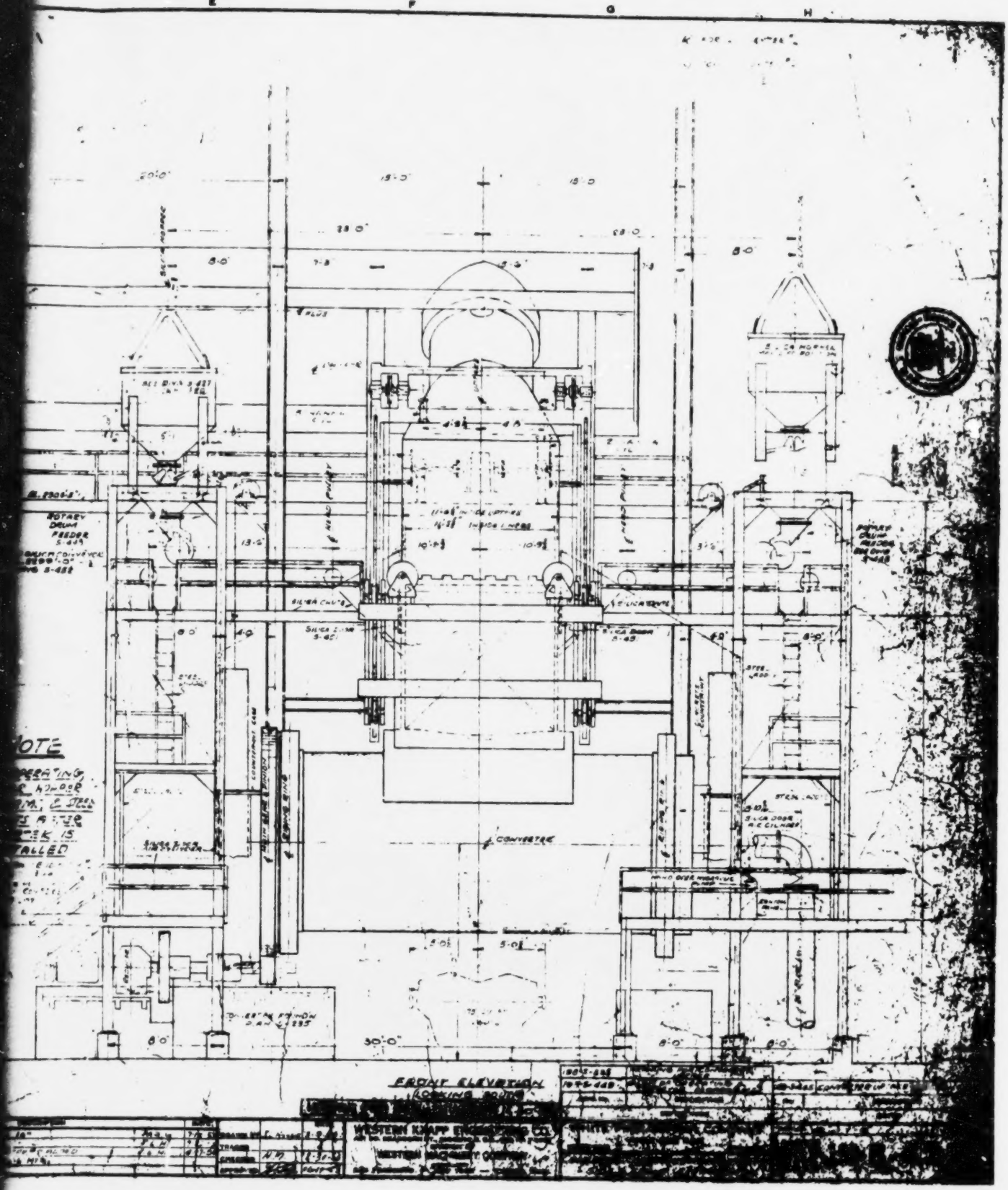

E
F
G
H
ROTARY DRUM FEEDER
CONVERTER
FRONT ELEVATION
WESTERN KNAPP ENGINEERING CO.

Figure 6.

27 MCFH. The dryer general specifications are as follows:

CONCENTRATE DRYER

General Specifications

Combustion Equipment - Hauck Mfg. Co.

Model - No. PRN 10442

Type - Direct Fired

Range - 7,500,000 to 36,000,000 BTU/HR

Burner Blower HP - 40

Dryer - Hardinge Division of Koppers

Model - Class XH-24

Size - 70' long x 10' dia., 316 ss construction

Drying Eff. - 70% Based on maximum throughput.

Drive HP - 125

Dust Collector - Krebs Elbair two stage wet scrubber

Inlet Load - 3 grs/ACF at 150° to 200°F and 14.44 Psia

Guaranteed Collecting Eff. - 99.5% by weight

Pressure Drop - 2 inches water gauge

Water Consumption - 300 gpm

Discharge Temp. - 120°F saturated

Exhaust Fan HP - 50

Volume - 30,000 SCFM

Scrubber Pump HP - 20

Auxiliary Material Handling

Feed System - 24 screw feeder, 15 HP

Discharge Conveyor - 24" belt, 175 fpm, 7½ HP

d. Other Emitting Equipment

Material handling, mixing and drying in the rotary dryer can produce particulate emissions but these are controlled by maintaining 9% moisture

in the mixed charge and scrubbing the dryer offgases.

Refining furnace (2) offgases are vented to a separate 90 foot tall stack. The refining furnaces generate small quantities of SO_2, NO_x, and particulate.

Leaks in ducts and at other pieces of equipment can generate SO_2 and particulate.

Ladles holding matte and slag (175 cu. ft. and 225 cu. ft.) will produce visible fugitive emissions.

E. EXISTING CONTROL EQUIPMENT

An electrostatic precipitator, flat plate type, was installed in 1971 to control particulate emissions from the reverberatory furnaces. The precipitator consists of two parallel chambers each two sections in series. The guaranteed collection efficiency was 95.4% but the actual efficiency is reported to be 90%. Source testing conducted in May, 1975, indicated that at an inlet dust loading of 2.817 gr/SCF, the outlet grain loading was 0.213 gr/SCF (Ref. 3). The precipitator was designed by Joy Manufacturing, Western Precipitation Division to handle 130,000 ACFM at 500°F and located between the Reverberatory Furnace Building No. 1 and the Reverberatory Balloon Flue (see Figure 4).

A two stage wet scrubber (Krebs Elbair) with guaranteed collection efficiency of 99.5% provides particulate control for the rotary dryer. A 50 HP exhaust fan is needed to transport the gas to the stack. The wet scrubber, installed in 1969, employs the so-called rebound principle. Water is sprayed in the direction of the gas flow against a rod screen. A rebound zone of atomized liquid droplets is established at the rod screen surface. A high collection efficiency is achieved at relatively low pressure drops, typically 2 to 3 inches w.c.

F. GAS SYSTEM DUCTWORK

The gas system ductwork for the reverberatory furnaces and converters is shown in plan view in Figure 4. The reverberatory furnace gases after

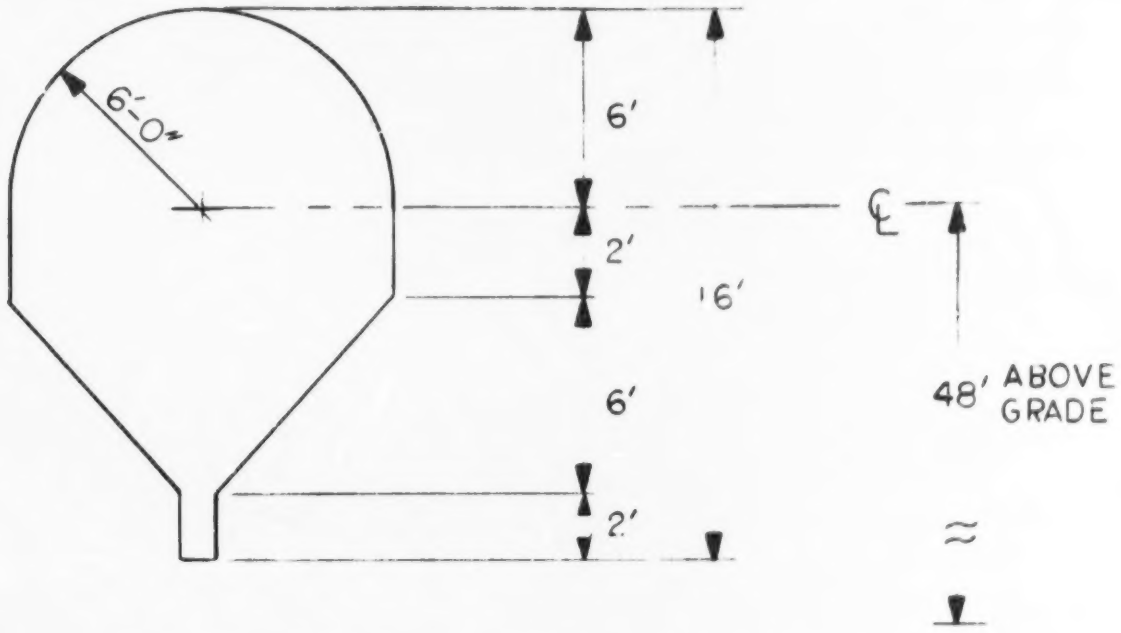
passing through waste heat boilers are collected in a balloon flue. The flue gases are treated in the electrostatic precipitators and then pass through a second leg of the balloon flue to the 500 foot main stack. A dimensioned cross section view of the balloon flue is shown in Figure 7. The reverberatory balloon flue between the "turn point tower" and the stack is approximately 275 feet long. The flue centerline is about 50 feet above grade. A bypass is available in case the precipitators are down.

The converter flue gases are collected in hoods and travel through a 188 foot balloon flue directly to the main stack. The converter balloon flue centerline is about 50 feet above grade. A cross section view of the converter balloon is also shown in Figure 7.

G. SULFUR BALANCE AND GAS COMPOSITION AT SYSTEM EXIT

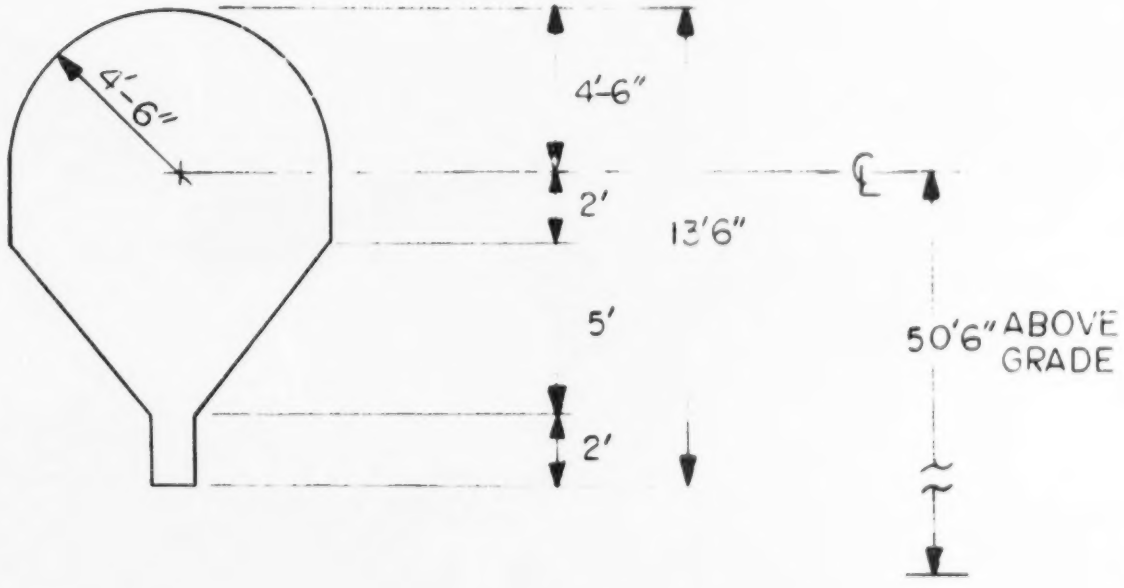
Typical Sulfur Balance Data
Based on Data from Reference 1

		TPD
Sulfur in		
Reverberatory		108.2
Secondaries		4.9
	Total	113.1
Sulfur Fixed		
Reverberatory slag		3.4



REVERBERATORY BALLOON FLUE

CONVERTER BALLOON FLUE



FLUE DIMENSIONS	
WHITE PINE SMELTER, WHITE PINE	PREPR'D AUG 19-75
PACIFIC ENVIRONMENTAL SERVICES	

FIGURE 7

Sulfur emitted to the stack		TPD
Reverberatory offgas		19.2
Converter offgas		88.3
	Total	107.5

Fugitive sulfur emitted to	
Atmosphere	2.2

When the converters are not operating (13.5 hours/day) the stack gas conditions at the 250-foot level are 269,000 ACFM (160,000 SCFM) at 370°F. The SO_2 concentration in the reverberatory furnace offgas range from about 0.1 to 0.2% SO_2. With the reverberatory furnaces and converters operating (10.5 hours per day) there are 366,000 ACFM (203,000 SCFM) at 430°F. Converter offgases are estimated to contain an average of 4% SO_2.

Recent test data obtained by the smelter indicate the following values:

REVERBERATORY AND CONVERTER FLUES MATERIAL BALANCE

Reverberatory Furnaces (2) (Precipitator Output)

Gas Volume Flow Rate	166,900 SCFM @ 498°F (Avg.)
Particulates	307 lbs/hr
SO_2	2,822 lbs/hr (0.16% b.v.)
SO_3	181 lbs/hr (81 ppm)
H_2O	3.7% b.v.
O_2	11.9% b.v.
CO_2	7.3% b.v.

Converters(s)

Gas Volume Flow Rate	106,855 SCFM @ 487°F (Avg.)
(Average of the three normal operating blow periods)	
Particulates	338 lbs/hr
SO_2	48,222 lbs/hr (4.2% b.v.)
SO_3	224 lbs/hr (157 ppm)
H_2O	2.6% b.v.
O_2	17% b.v.
CO_2	1.8% b.v.

1st slag blow = 98,783 SCFM (@ 464°F. Ave. Operating)
2nd slag blow = 142,217 SCFM (@ 450°F. Ave. Operating)
Copper Blow = 106,383 SCFM (@ 546°F. Ave. Operating)

Reference 2

H. GAS CHARACTERISTIC VARIATION

It can be expected that SO_2 concentration in the offgas from the reverberatory furnace will vary significantly with time. This results from the variation in time required for decomposition or reaction of the various sulfide ores charged to the furnace. The SO_2 concentration has been known to vary as much as 10 to 1 within a given charging time cycle. While no data are yet available from this smelter concerning this point, it should be considered for control system design. The furnaces are charged one side every 1/2 hour for a period of 18 hours each day. Thus each side receives a charge every 2 hours.

The SO_2 concentration in the converter offgas will also vary considerably for an entirely different reason. The operation of a converter includes two slag blows and one copper blow. Between these blows the converter may be rolled out for slag pouring or material charging. The attempt is always made to maintain at least one converter blowing at any given time. Usually a converter will be provided with 18,000 to 20,000 SCFM to the tuyeres. An additional 100 to 120% of dilution air is generally estimated to be added to this gas flow resulting in a total gas flow from each converter in the range of 35,000 to 40,000 SCFM.

As can be seen from the above data in Section G, the average converter gas flow has been measured to be 106,855 SCFM. This would imply a considerable increase in dilution air which may result from a large gap at the converter hood or duct leakage.

I. STACK DESCRIPTION

Main Stack

Height	504 feet
Diameter	15 feet @ top, 40 feet @ base
Draft	2.75" w.c.

Main Stack (continued)

Construction	Acid proof brick lining, fiberglass insulation, reinforced concrete exterior Temperature limitations 300° to 600°F Dew point 170°F to 230°F

Two Refining Furnace Stacks

Height	90 feet each
Diameter	2'-6" and 3'-0"
Draft	0.8 to 1.0" w.c.

J. PRESENT TECHNIQUE FOR SOLID WASTE HANDLING

Slag from the reverberatory furnace is taken to the slag dump. Slag from the converters is recycled to the reverberatory furnaces. Flue dust captured in hoppers is recycled.

K. FOOTING REQUIREMENTS AND STRUCTURAL CRITERIA

If construction is to be carried out in some areas, footing tests would be required. A major portion of the area adjacent to the smelter is coal storage areas and slag dumps. It will be necessary to conduct footing tests to determine detailed footing requirements. However, if slag is assumed for determining requirements then each position would have to be dug out and footings placed on undisturbed soil with design loading of 3000 PSF. No local codes apply. The White Pine smelter is located in seismic zone 0. The Uniform Building Code (UBC) specifies the following design criteria:

Wind load	30 PSF at 30 feet above grade
Snow load	40 PSF reduced by 1 lb PSF for each degree of roof slope over 20°

A more complete list of design criteria, prepared by Bechtel Corporation during the smelter design, are included as Appendix B.

L. EXISTING AND POTENTIALLY AVAILABLE UTILITIES

Electrical: All smelter substations are loaded to design capacity except for S3A which could handle about 200 additional KVA. Any additional capacity could be very costly, depending on just what is required.

Water: Present facilities are loaded to maximum.

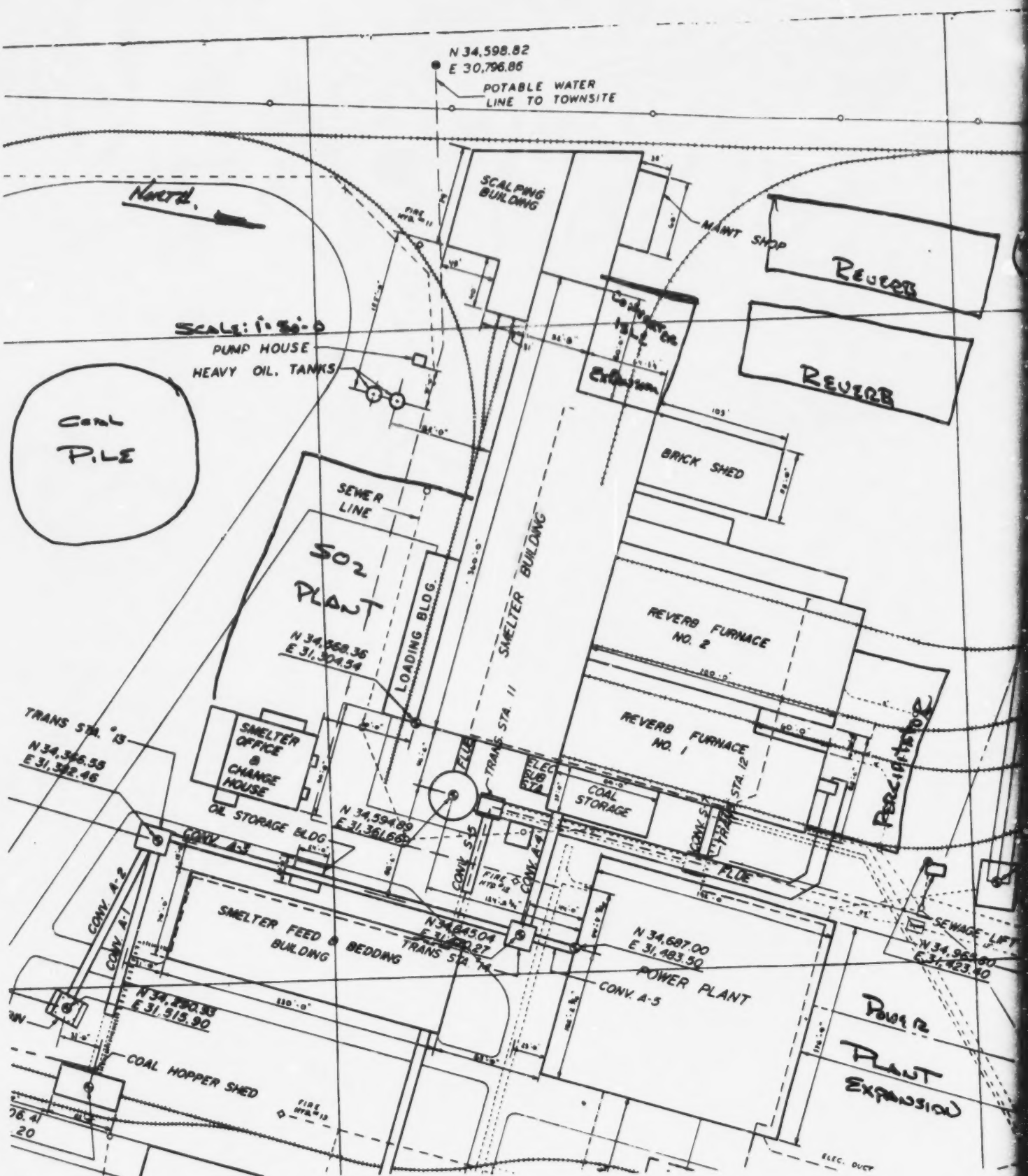
Gas: Present firm gas contract expires early in 1978. Availability of gas beyond that date is at present unknown. White Pine Planning anticipates greatly reduced gas after January, 1978.

Steam: Steam available in smelter is used for electric power generation, building heat, and the heating of reverberatory furnace combusion air. There is no surplus steam available and little or no space available in present buildings for an orderly engineering boiler installation.

M. POTENTIAL NEW CONTROL EQUIPMENT INSTALLATION AREAS AND PROBLEMS

Sludge or water containing dissolved metals and solids disposal will be a potential problem at this smelter. Waste material that may result from the operation of a control system will be discharged to the tailings pond processed and, eventually, the cleared water will enter the local creek, river and lake system. The present fluid waste handling system is operating at near maximum capacity and additional facilities will probably be required.

Figure 8 shows suggested areas for control systems as well as reverberatory furnace, converter and power plant expansions. Sufficient space appears to be available.


N 34,598.82
E 30,796.86
POTABLE WATER LINE TO TOWNSITE
North
SCALPING BUILDING
MAINT SHOP
REVERB
REVERB
SCALE: 1"=50'-0"
PUMP HOUSE
HEAVY OIL TANKS
COAL PILE
BRICK SHED
SEWER LINE
SO2 PLANT
N 34,968.36
E 31,304.54
LOADING BLDG.
SMELTER BUILDING
REVERB FURNACE NO. 2
REVERB FURNACE NO. 1
TRANS STA. 13
N 34,346.38
E 31,392.46
SMELTER OFFICE & CHANGE HOUSE
OIL STORAGE BLDG.
N 34,594.89
E 31,361.66
TRANS STA. 11
ELEC. SUB
COAL STORAGE
TRANS STA. 12
PERCOLATING TOWER
FLUE
CONV. A-3
CONV. A-2
CONV. A-1
CONV. S-5
CONV. A-4
SMELTER FEED & BEDDING BUILDING
N 34,845.04
E 31,220.27
TRANS STA. 14
N 34,687.00
E 31,483.50
POWER PLANT
CONV. A-5
SEWAGE LIFT
N 34,969.90
E 31,423.40
N 34,490.33
E 31,915.90
COAL HOPPER SHED
POWER PLANT EXPANSION
ELEC. DUCT

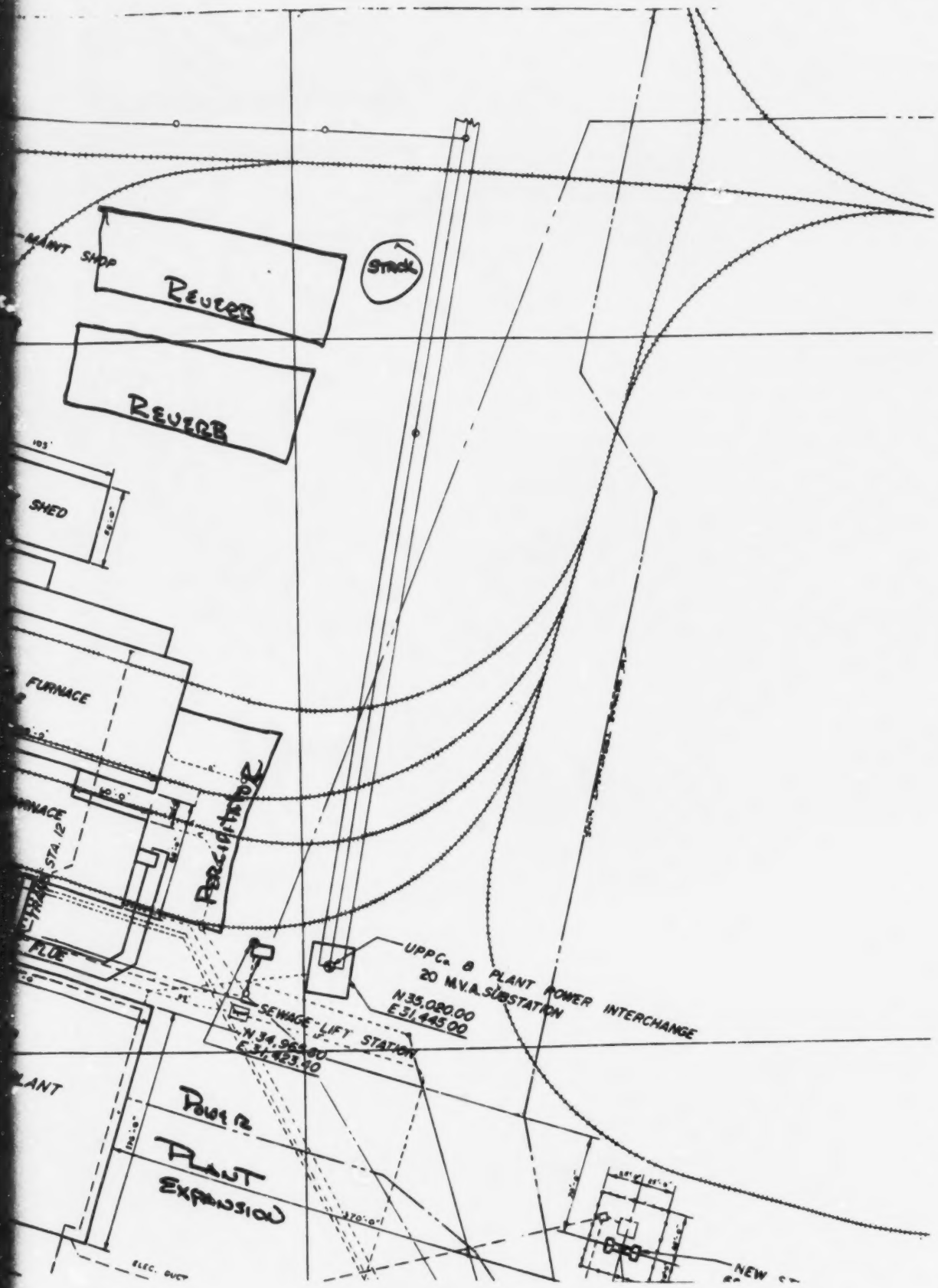

MAINT SHOP
REVERB
REVERB
STACK
SHED
FURNACE
FURNACE
STA. 12
PERLITE STORE
FLUE
UPPC. B PLANT POWER INTERCHANGE
20 M.V.A. SUBSTATION
N 35,080.00
E 31,445.00
SEWAGE LIFT STATION
N 34,964.80
E 31,433.40
PLANT
POWER
PLANT
EXPANSION
ELEC. DUCT
NEW

Figure 8.

REFERENCES

1. "Typical Smelter Data" White Pine Smelter, 1974

2. Letter from J.W. Maksyn, Environmental Control Engineer to I.J. Weisenberg dated July 24, 1975.

3. Personal Communication with J.W. Maksyn, Environmental Control Engineer; October 6, 1975.

APPENDIX A

WHITE PINE COPPER COMPANY - SMELTER OPERATION

At the end of the mill process, a copper bearing concentrate (filter cake) of approximately 30-32% copper and 18-22% moisture is produced. The next step in the process is to flux this material to obtain good smelting characteristics. Lime is added to enhance the fluidity of the slag in smelting and to lower the smelting temperature of the mixed charge. Currently, tests are being conducted to eliminate the need for pyrite fluxing. By volume, a dry mixed charge contains 69% mill concentrate, 19% limestone, 8% pyrite, and 4% recycle material.

Once the addition of fluxes has been made to the filter cake from the mill, the material is directed thru a large rotary type dryer. Here, the moisture content is reduced to 9%. Removing the moisture at this point rather than at the furnace has significantly increased the furnace smelting capacity. The 9% moisture left in the mixed charge gives us a material which is suitable for handling in that the relative small quantity of moisture remaining prevents dusting. Another important function of the rotary type dryer is the blending of the fluxes uniformly in the mixed charge which provides a more uniform feed for smelting.

Through a network of conveyors, the dry fluxed concentrate (mixed charge) is transported to a level above the two large reverberatory furnaces. (See following flow sheet). A shuttle conveyor operates above the furnaces introducing the mixed charge into the furnace through a series of water cooled charge chutes on either side of the furnace. The mixed charge forms charge banks along the internal walls of the furnace. This charge bank extends approximately 2/3rds the length of the furnace. Simultaneously, the reverb furnace is fired with a fuel mixture of pulverized coal and preheated air. Furnace arch temperature is maintained at approximately 2600 degrees and melting of the charge banks is a continuous process. Once in the liquid form, two definite molten materials are recognized; slag which is the lesser viscous material, and matte which is the heavier copper bearing material. The molten combinations flow into a settling zone near

the uptake end of the furnace and a distinct separation takes place. You will note the difference of elevation of the tap holes on the side of the furnace wall. The upper elevation hole permits the "tapping" of slag wastes, while the two lower holes are used for extracting matte.

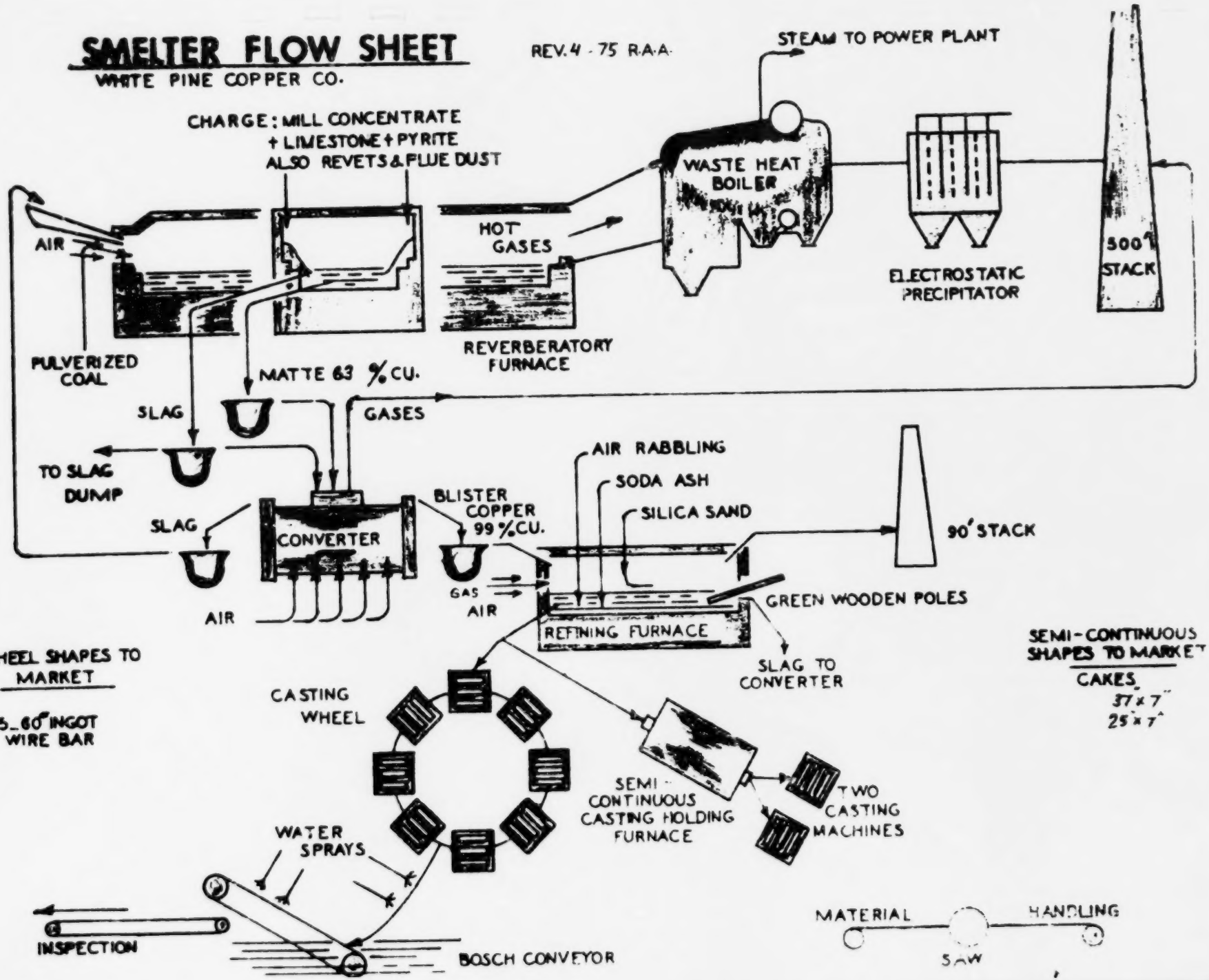
The matte produced in the reverberatory operation is transported in large ladles to one of two convertors. The convertor operation can be thought of as a means of promoting further separation of copper from the gangue material. The convertor is a cylindrical holding vessel laid on it's side and employing a means of rotation. The opening into the convertor is referred to as the mouth. Opposite the mouth of the convertor, on the opposite wall, the convertor is fitted with a series of air pipes called "tuyeres". In the converting process, these tuyeres are rolled beneath the bath and air is forced into the liquid charge. The oxygen reacts with the iron and forms an iron oxide slag which is removed in the skimming process. The oxygen also reacts with the sulphur to form a sulphur gas which is carried off in the exhaust air stream. The convertor charge is slagged off in the skimming process and the resulting charge is 80 tons of "blister" copper ready for transfer to one of two refining furnaces.

The refining method used at White Pine is one of the very few "fire refining" processes in existance today. Due to impurities and the presence of other minerals in other copper producers ores, they have been forced into a more costly method of electrolytic refining. Refining begins after three (3) convertor charges, or 240 tons of copper have been transferred from the convertors. Approximately 8000 # of soda ash is blown into the bath using compressed air and pipe lances. A soda slag cover is formed over the bath and the bath is "rabbled" (stirred) using a series of 3/4" air pipes.

SMELTER FLOW SHEET

WHITE PINE COPPER CO.

REV. 4 - 75 R.A.A.



APPENDIX B

PLANT DESIGN CRITERIA

A. GENERAL

These data, related to the physical design of the plant, were established by studies, conferences and correspondence between White Pine Company representatives and Bechtel Corporation.

Installations will be designed and constructed as permanent and having an estimated 20-year life. Provisions will be incorporated in the design and considered in the selection of equipment for sub-zero operation where required. Full consideration will be given to the protection and comfort of operating personnel.

The plant design will be in compliance with existing codes, governmental regulations, Factory Insurance Association and White Pine Copper Company Safety Rules and Regulations dated 1962.

B. CLIMATIC DATA

Composite average of U.S. Weather Bureau Station records at Ontonogan, Bergland, Marquette and Duluth.

1. Temperature

a. Highest Recorded Temp. ^{o}F	$102^{o}F$
b. Lowest Recorded Temp. ^{o}F	$-33^{o}F$
c. Mean yearly temp.	$42^{o}F$
d. Mean daily max. temp.	$52^{o}F$
e. Mean daily min. temp.	$31^{o}F$
f. Mean no. of days temp. above $90^{o}F$	4 days
g. Mean no. of days temp. below $32^{o}F$	186 days

2. Precipitation

a. Yearly average total (in.)	32"
b. Snowfall (in.)	173"
c. Percent precipitation in form of snow	35%
d. No. of days precipitation over 0.10"	81 days
e. No. of days precipitation over 0.50"	18 days
f. Max. snowfall in 24 hr.	25"

3. Winds

a. Daily Average	9 MPH
b. Max. Winds once in 20 years	75 MPH
c. Max. Monthly range	50 MPH

C. CIVIL

1. Plant Datum

To convert USC & GS topographic elevations to plant datum, add 4396.44 feet.

2. Fire Protection System

Materials and arrangement details of the fire protection facilities set forth herein will conform with the requirements of the Factory Insurance Association (FIA). Underground fire lines will be cast iron pipe with mechanical joints with ductile iron retainer glands at all fittings, thereby eliminating the need for thrust blocks. Sectionalizing valves with post indicators will be provided to isolate various sections of the system for maintenance or repair. Hydrants will be dry barrel type with one pumper connection and two hose outlets.

3. Utility Systems

Utility piping between the various facilities will be generally run underground. Water lines subject to freezing will have a minimum cover of 6 feet in areas not normally cleared of snow and 10 feet at roadways. All underground lines will be sloped to low points with provisions for draining.

4. Clearing

Brush and trees will be removed from the graded plant area to a line 20 feet beyond the top of cuts and toe of fills and 100 feet from structures. Stumps will be grubbed from areas to receive fills for structures, roads, railroads and parking areas. All organic material removed as part of the clearing and grubbing operations will be disposed of in waste areas or burned.

5. Earthwork

a. Excavation

Cut slopes in excavated areas to be left exposed will be no steeper than 1-1/2:1 in overburden and 1/2:1 in rock. Structural excavation in rock will be performed in a manner to prevent the fracture of rock on which structures will be founded. For future expansion, if required, rock will be drilled and blasted to foundation elevation for all future structures within 100 feet of initial construction.

b. Embankments

Fills for roads and parking areas except as filled by mine waste will be obtained from excavated areas, placed in successive layers and compacted to 95% of maximum density as determined by ASTM Designation D-1557-64 T. Fills on which structures will be placed will be select granular material obtained from the site or imported as required and compacted to 100% of maximum density. Fill slopes will be no steeper than 1-1/2:1.

6. Roads and Parking Areas

a. Access Roads

The facility access roads will have a surfaced width of 24 feet with 4-foot stabilized aggregate shoulders. Surfacing will consist of bituminous plant mix having a compacted thickness of 2 inches placed on an 8-inch stabilized aggregate base course.

b. Plant Roads

Secondary roads at the facility will have the same surface and base as the access roads, but will be only 20 feet wide with 4' stabilized aggregate shoulders.

c. Parking Areas

Parking areas will have a 2-inch bituminous plant mix surface placed on a 6-inch stabilized aggregate base course and will slope to drain by sheet runoff to the east.

7. Storm Drain System

Culvert and ditch capacities will be based on anticipated run off from a storm having a frequency of occurrence of ten years. Runoff from storms of greater intensity will cause localized ponding for a few minutes; however, such ponding will be controlled to prevent flooding of structures or roads.

a. Erosion Control

Runoff from above the top of excavated slopes will be intercepted by ditches and conveyed down the slope in ditches or conduits to natural drainage channels.

b. Surface Drainage

Runoff from graded areas will be conveyed in a system of open ditches discharging to natural drainage channels. Culverts with a minimum diameter of 12 inches will be placed where required under roads and railroad. Headwalls or prefabricated end sections will be provided at culvert inlets and outlets. Riprap will be used where required to control scour.

c. Subsurface Drainage

Subsurface drains consisting of perforated pipe with gravel encasement will be provided where necessary to relieve hydrostatic pressure against subsurface structures. Subsurface drains will discharge to natural drainage channels or to pump sumps within the structure.

D. STRUCTURAL CRITERIA

1. Codes

The general design of all building structures will be in compliance with the 1964 edition of the Uniform Building Code (UBC) of the Pacific Coast Building Officials Conference.

Structural steel will be in accordance with the American Institute of Steel Construction Specification for the Design, Fabrication and Erection of Structural Steel for Buildings, 1963 edition.

Reinforced concrete will be in accordance with the American Concrete Institute Specification 318-63.

Light gauge cold-formed steel structural members will be in accordance with the American Iron & Steel Institute Specification.

Welding procedure will be in accordance with the Standard Code for Arc and Gas Welding in Building Construction, AWS-D1.0.

2. Live Loads

Office area floors	50 PSF
Floors for walkways	75 PSF
Conveyor walkways	50 PSF
Stairs and Landings	100 PSF
Laydown areas and truck aisles	200 PSF*

*To be checked against equipment operating wt + 75 PSF on uncovered floor used as walkway.

Service Platforms 250 PSF

Roof-UBC Section 2305-40 PSF reduced by 1 lb PSF for each degree of roof slope over 20°.

Wind-UBC Section 2308-30 PSF at 30 ft above grade.

Ore Bins -	Angle of repose of ore	38°
	Ratio of lateral to vertical pressure	0.3
	Wt. per cu ft of ore	100 lbs.

Seismic - UBC Section 2314 Zone 0

Major equipment foundations will have a minimum weight 2-1/2 to 3 times the revolving combined weight of the equipment, charge and ore.

Highway truck loading AASHO H20-S16-44

3. Allowable Bearing Values Assumed

Owner will furnish soil bearing pressure recommendations upon completion of its soil testing program. A soil pressure of 4500 PSF for miscellaneous structures and a one-third increase in stress for combinations including wind or seismic loads will be assumed. Footings subjected to overturning forces will be designed so the resultant falls within the middle third of the footing.

Frost Line is established at 5.5 feet below finished grade.

4. Concrete

Concrete will be designed for 3000 PSI at 28 days.

Lean concrete fill will be designed for 1500 PSI at 28 days.

5. Structural Steel

Structural steel exposed to atmospheric temperatures or for use in unheated areas will conform to ASTM serial designation A 131 Grade B for material to 1 inch thickness and A 131 Grade C for material over 1 inch thickness. In other areas ASTM serial designation A36 will be used.

6. Miscellaneous Steel

Minimum requirements for miscellaneous steel will conform to ASTM serial designation A7.

E. ARCHITECTURAL

In general the National Building Code and National Fire Underwriters Code will be used in the development of the building designs for this project where it does not conflict with FIA requirements. The remainder of the design criteria will be as supplied by the Owner and as dictated by economy consistent with the requirement of site conditions, climate, process and 20 year life of the project.

The architectural materials and details not specified by the Owner, will be chosen for their durability, their maintenance-free qualities and economy. Because of the subzero temperatures and heavy snow fall, the walls of heated buildings will be insulated and protected at their bases by concrete sill walls. Exterior doorways will be furnished with canopies for protection from falling ice.

Structural steel framing will be fabricated to allow for future expansion.

Provisions will be made for relocating wind columns and girts.

All buildings will be of rigid frame prefabricated construction with insulated steel roofing and siding panels, set on a reinforced concrete foundation and floor slab on grade and will be designed in accordance with structural criteria listed above.

Manufacturer and model numbers are shown to indicate quality. Equal materials of other manufacturers may be substituted when approved by Owner.

1. Materials

The materials described herein apply to all new structures and additions to existing structures, in so far as applicable.

Prefabricated Building - Building manufacturers standard prefabricated rigid frame steel building, gable roof type, with insulated prefinished formed metal roofing and siding, with metal doors and windows, and with all necessary framing, hardware and accessories.

Acoustical Ceilings - Acoustical Tile, 3/4 inch thick, with a Noise Reduction Coefficient of .75 and a flame spread of less than 25, supported on an exposed aluminum tee grid suspension system, to form a completely accessible and demountable ceiling system.

Ceramic Tile - Unglazed ceramic mosaic floor tile and glazed ceramic wall tile, with coved base and wainscot cap.

Concrete Block - Hollow load bearing masonry units, made with light weight aggregate, laid in running bond.

Drywall Construction - 5/8 inch thick, fire rated, gypsum wallboard, on metal studs, with wallboard joints taped and corners reinforced.

Metal Doors - 1-3/4 inch thick hollow core, flush steel doors in pressed steel frames, complete with hardware. Doors in movable metal partitions will be the manufacturer's standard flush steel doors, metal frames and hardware.

Movable Metal Partitions - Sound insulated, flush type partitions. Partitions will be of the glazed and unglazed type, extending from finish floor to finish ceiling, and will be completely demountable and reuseable for maximum flexibility of room rearrangement.

Painting - All exposed surfaces, except prefinished surfaces will, in general, receive three coats of paint. Shop primed surfaces will be touched-up as required, and be finish painted. Concrete and masonry surfaces will be painted.

Resilient Flooring - 1/8 inch thick vinyl asbestos floor tile with vinyl topset base for application on concrete floor slabs.

Stairs - Metal pan, closed riser stairs with cement filled treads and safety nosing, complete with stringers, handrails, and landings.

F. MECHANICAL

1. General

Equipment proposed will be of the type as listed in Section VI-Equipment List. Final selection of equipment will be predicated on suitability of equipment offered, quality, price and economy of operation and maintenance.

2. Conveyors

All conveying equipment will be heavy duty and suitable for operation at extremes of temperature expected. Belting will be best grade for the specific conditions. Conveyor idlers will be of heavy duty construction with 60,000 hour rated sealed anti-friction bearings. Head and tail pulleys will be welded steel heavy duty construction. Lagging will be used where required. Take-up will be vertical gravity type wherever possible. Pillow blocks will be heavy duty with 60,000 hour rated sealed anti-friction bearings. Speed reducers will be of standard design and use sealed anti-friction bearings. Holdbacks, where required, will be separate from speed reducers. Wherever possible, components will be standardized. All conveyors will include belt cleaners or scrapers at the head pulley.

3. Dust Control

Dust control facilities when provided to minimize the escape of dust to the atmosphere will be of the wet type.

4. Duct Work

Duct work upstream of collectors will be provided with rubber lined fittings to minimize erosion and straight runs will be constructed of 10-gauge mild steel sheet. Duct work downstream of collectors will be provided with 12-gauge fittings and 14-gauge will be provided on straight runs. Cleanouts will be provided at the beginning of horizontal runs.

Duct velocities will be maintained between 3000 and 4000 FPM. Dust collecting systems will be balanced insofar as possible using the "duct sizing" method; that is, the system will be in balance without depending upon blast gates or orifice plates. However, blast gates (and not butterfly dampers) or orifice platee (bottom eccentric) may be required in some cases, particularly on relatively short runs where the velocity is at its prescribed maximum.

5. Pumps

In selecting pumps and motor drives, due consideration will be given to surges and overloads which may be expected in the systems. In general, pumps will be accessible by fork lift for maintenance except in a few areas and in the case of vertical pumps where this arrangement is not practical. For such cases, provisions will be made for removal by overhead hoist or crane.

Sand pumps will be V-belt driven and in general will be rubber lined. Where possible, motors will be mounted directly over and above the pumps.

Water pumps will be of cast iron construction and generally will be direct connected to their motors through flexible couplings.

Pump sumps in general will have a capacity equivalent to 1-1/2 minutes surge time with the exception of the mill discharge and primary and secondary classifying cyclone feed pump sumps which will have capacities in slight excess of 1/2 minute each. The size of these sumps are limited by layout considerations.

6. Piping Systems

Process piping will be in accordance with the ASA Code for pressure piping.

Fuel oil and 150 psig steam will be all steel welded systems with 150# flanges where required.

Water, compressed air and space heating steam will generally be as follows:

a. Weld end pipe and 125# CI flanged valves for 2-1/2" and over.

b. Screwed pipe and 200# bronze valves for 2" and under.

Ore pulp systems will be standard weight carbon steel pipe for all sizes, grooved for victaulic coupling where required.

Tailings lines may be spiral weld pipe.

7. Insulation

Lines operating at temperatures in excess of 140°F will be insulated for conservation of thermal energy, or personnel protection, with the exception of the fuel oil system which will be insulated and steam traced in its entirety. In addition, due consideration will be given to insulating and/or protecting lines exposed to weather to prevent freezing.

Inside lines requiring thermal insulation will be covered with a single layer of sectional pipe insulation. Generally,

equipment requiring insulating will be covered with insulation in block form. The insulated items will be covered with a loose weave fiberglass cloth thoroughly impregnated with an adhesive material.

Outside lines requiring thermal insulation and equipment above ground will be covered with sectional or block insulation to suit. The insulation will be fastened in place by wire bands and covered with an application of a weatherproof coating of black asbestos filled water soluble asphaltic emulsion applied over hexagonal wire mesh fastened to the insulation.

Buried lines requiring insulation will be embedded in gilsonite and will require no other insulating covering.

G. ELECTRICAL

1. General

The existing electrical system will be modified and expanded to include all additional material and equipment for power, control, grounding, lighting, instrumentation and annunciation.

Simple radial electrical power distribution will be employed and the system will be designed to keep the plant power factor at 0.9 or above, using synchronous motor drives.

Medium voltage cable will be carried in conduit, duct or armor. Conduit will be used extensively for low voltage systems throughout the plant with some use of cable tray where conditions are suitable.

Protective relaying and metering will be provided for all voltage levels for both distribution systems and installed equipment.

2. Voltage Levels

The voltage levels as established in the design of the existing plant will be followed. A basic primary distribution voltage of 13.8 kv will be employed for distribution to plant load centers. Utilization voltages will be 4160 volts or 480 volts for power equipment 1/2 hp and over.

3. Equipment Enclosures

Electrical equipment located out-of-doors will be provided with NEMA 3 weather protected or NEMA 4 water-tight enclosures.

Electrical equipment located in operating areas will be provided with NEMA 12 liquid and dust-tight gasketed enclosures. NEMA 1 enclosures will be used for equipment installed in electrical rooms and other locations where freedom from dust is maintained by filtered air supplies and moisture is not prevalent.

Electric motors will be open-dripproof type with premium shielded insulation to minimize absorption of moisture and attack from abrasive dust and chemical reagent vapors.

4. Lighting Levels

Average maintained lighting levels and assumed maintenance factors for the expansion program will be as follows:

Location	Illumination	Factor
Operating Areas	30 foot candles	0.60
Conveyor Ways	10 foot candles	0.65
Yard & Roadways	1 foot candle	0.75
Offices, control & electrical rooms	50 foot candles	0.75
Shops & Warehouses	40 foot candles	0.65

5. Codes and Standards

All equipment will conform to the latest applicable standards of IEEE and NEMA for design, construction and tests. Electrical system design and construction will conform to standards required by the National Electrical Code.